

## **Written opinion on the description of the invention "Thermonuclear reactor with a Z-shaped magnetic field"**

The scrutiny of the published description of Anatolii I. Kharchenko's invention "Thermonuclear reactor with a Z-shaped magnetic field" , which passed the stage of formal examination at Ukrpatent a201812178, as well as with the description of the same invention published according to the international PCT procedure on the WIPO website (publication WO2020/122853) , allows us to draw the following conclusions.

1. The project of a thermonuclear reactor presented in the description uses colliding plasma beams of quasi-neutral plasma, to which a high potential difference (from tens of kilovolts to megavolts) is applied before their meeting, which certainly creates the possibility of thermonuclear reactions at the meeting area of the beams for such types of thermonuclear fuel as deuterium , a mixture of deuterium with tritium, a mixture of hydrogen with boron-11.
2. The presented reactor differs from the rest of the modern patented thermonuclear reactors with colliding plasma beams and from the rest of the modern linear fusion reactors with magnetic plasma confinement in that a high-voltage discharge is creating between the plasma beams at the meeting area, which makes it possible to obtain a thermonuclear plasma temperature at the meeting area beams with the highest efficiency for converting the consumed electrical energy into thermal energy of the plasma (the efficiency of such a process with a discharge between electrodes is more than 80%, the efficiency of modern plasma accelerators KSPU is up to 80%).
3. The movement of plasma beams to the meeting point prevents the formation of pinches that impede the discharge, which was a problem for previous models of thermonuclear reactors using a plasma discharge (like ZETA).
4. The plasma concentration at the meeting area exceeds the plasma concentration in the initial beams due to its retention at the meeting area (bending of the magnetic field).
5. Additionally, the plasma concentration at the area where the plasma beams meet is higher than the concentration in the initial beams due to a decrease in the radius of the beams by the magnetic field of the discharge (pinch effect).
6. At the meeting point of charged plasma beams, they have a nonzero angular momentum relative to the center of mass due to the shift of the axes of the magnetic field. Therefore, the occurrence of circular currents at the meeting area is inevitable. This process creates an additional effect of plasma confinement at the meeting area due to the magnetic field of the arising circular currents in the plasma. This increases the confinement time of the thermonuclear plasma in the Z-shaped bend. The exact confinement time depends on the engineering details of the particular installation.
7. Accurate calculations of the processes occurring in the specified reactor are impossible due to the inevitably arising in such installations effects of self-consistent behavior of charged particles in an electric and magnetic field, quantum and relativistic effects. In such experiments, the results differ significantly from those predicted theoretically. Therefore, the lack of precise mathematical calculations in the description of the invention seems justified.

8. Devices similar to the declared reactor have not been tested anywhere else. The process of collision of plasma beams in a Z-shaped magnetic field with a high-voltage discharge between them has not been previously studied and has not been described anywhere. The specific result on the efficiency of the declared reactor may depend on specific private engineering solutions in the proposed installation.

9. The cost of plasma accelerators for the declared reactor, depending on their parameters and equipment, is millions of euros, the same estimated value we have for the cost of vacuum equipment, high-voltage equipment, energy storage devices, devices for creating the necessary magnetic field, diagnostic and measurement equipment, equipment for regulation and control of processes in the reactor. Together with the costs of work, premises and scientific personnel, legal and other overhead costs, the total cost of construction of the said reactor and experiments on it will not exceed one hundred million euros.

### **Findings:**

- **The invention "Thermonuclear reactor with a Z-shaped magnetic field" by Anatolii I. Kharchenko surpasses modern analogous installations of linear thermonuclear reactors in parameters of efficiency , plasma temperature, plasma concentration and plasma confinement time.**
- **The invention "Thermonuclear reactor with a Z-shaped magnetic field" by Anatolii I. Kharchenko surpasses well-known modern thermonuclear reactors, including tokamak and stellarator, in terms of the efficiency of converting the supplied electrical energy into thermal energy of the plasma, in terms of plasma temperature and plasma concentration in the working area of the reactor.**
- **It is possible to experimentally verify the effectiveness of the described thermonuclear reactor with a total expenses of not more than one hundred million euros.**

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Photocopies of the originals of this written opinion signed by Alexander G. Vakhney in Ukrainian and Russian languages are on the pages:

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